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CARICOM Fisheries Resources Assessment Program (CFRAMP)

Food and Agriculture Organization of the United Nations

9 RED SNAPPER (*Lutjanus purpureus*) FISHERY IN FRENCH GUIANA

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9.1 Introduction

The Management Area is comprised between Maroni river, in the western part and Oyapock river, in the eastern part of the fishery (see Fig. 9.1). The potential surface of the fishery for red snappers is approximately of 26000 km^2, from the isobaths of 50-120m. It is harvested on the rocky grounds by a Venezuelan fleet of 41 licensed hand liners, from Pampatar and Carupaño (Table 9.1). The licences are nominative and free and assigned by the EU. Under the licence agreement, the skippers have to land and sell 75% of their catches to two processors in French Guiana with whom they have a production contract.

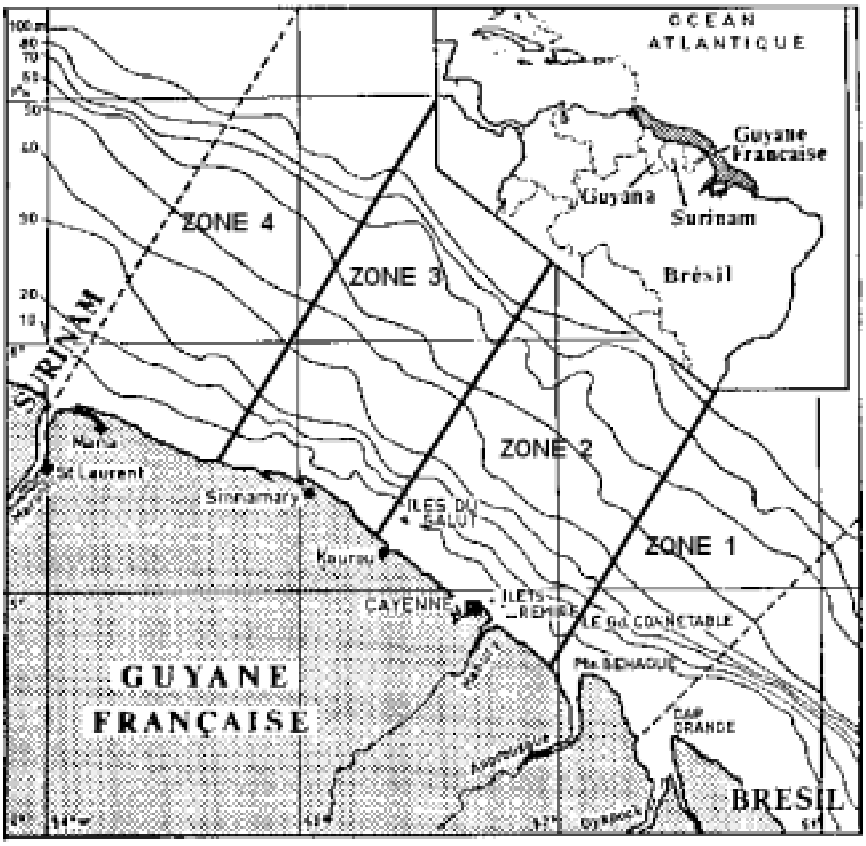

Figure 9.1 Map of the fishing zones for red snapper (*L. purpureus*) in French Guiana

A new fishery exploited by fishermen from La Martinique and La Guadeloupe was initiated in 1996. They operate with pots mainly on muddy grounds. That fishery is also targeting vermilion snapper (*Rhomboplites aurorubens*) and lane snapper (*Lutjanus synagris*). For this assessment, this new activity was considered too recent and too small to introduce significant trends in the fishery in 1997 and 1998. However, it is likely that in the next assessments this new factor must be introduced in the assessment of the red snapper.

Table 9.1 Summary of landings, effort and CPUE of *L. purpureus* on the fishery of French Guiana, from 1986 to 1997.

Year	No. of licensed boats		Mean no. of boats at sea	Effort (Days fishing)	Effort hours fishing	Landings (t)	CPUE (kg per hour)
	Venezuela	*Barbados**					
1986	20	5	9	1409	15635	677	50.6
1987	25	5	10	2875	33846	716	23.4
1988	25	5	13	2973	30951	1116	36.5
1989	35	5	20	5200	53234	1366	24.8
1990	35	5	18	4559	48898	1278	25.5
1991	35	5	20	4638	45879	1115	24.4
1992	41	5	18	5360	44700	1197	26.4
1993	41	5	19	4516	43844	1383	29.4
1994	41	5	20	4953	44580	1468	31.3
1995	41	5	17	5284	48996	1462	28.4
1996	41	5	27	9001	71645	2110	31.9
1997	41	5	23	7478	64729	1578	24.6
1998	41	5	28	7891	71244	1840	23.0

* These licences to Barbados were given by the EU under a scheme for ACP countries, but never used.

When Venezuelan boats return to Margarita approximately every quarter, they leave French Guiana with the equivalent of 25% of their total annual catch. In previous analysis that amount was not taken into account but it is used in the present assessment. An approximation is made for the estimation of the corresponding effort.

The timing of the fishing by Venezuelan fishermen is marked by two events:

- From April to June there is a decrease in monthly effort (Fig. 9.3) during the wet season in French Guiana.
- At the end of November and at the beginning of December, they return to Margarita, coming back to the fishery the following February.

The activity of shrimp trawlers is an important source of mortality for young red snappers. Preliminary evaluations of the number of juveniles caught during surveys by typical shrimp-trawlers give estimates as high as 1.5 to 2 million individuals caught by the French Guiana fleet.

Figure 9.2 Catches per unit effort (- - -) and total landings (—) of *L. purpureus*. There has been a slight decline in CPUE as catches have decreased (see also Table 9.1)

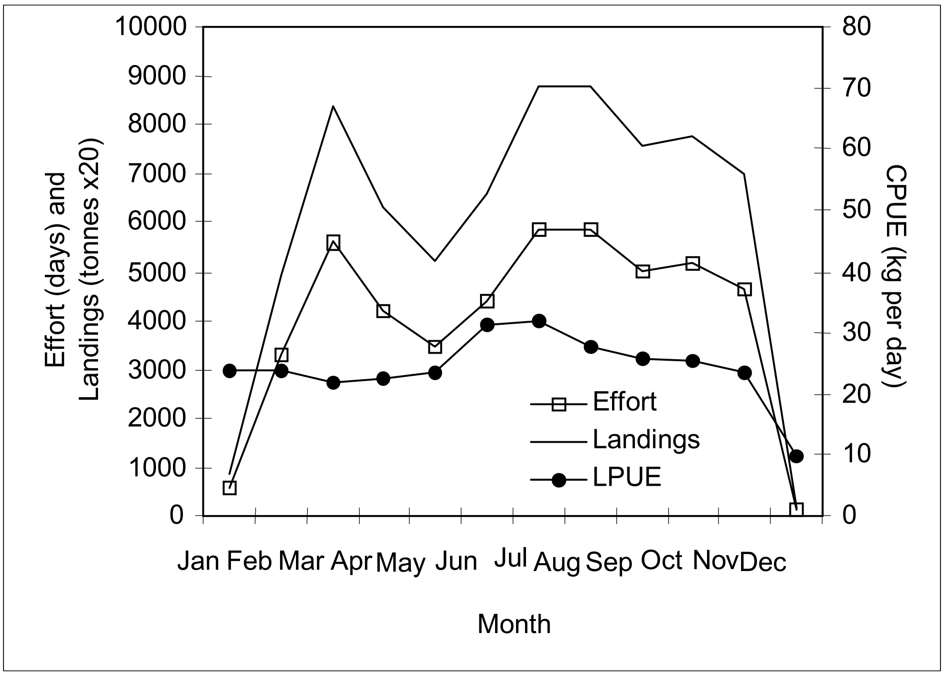

Figure 9.3 Effort, landings and CPUE of *L. purpureus* on the fishery of French Guiana on the series (1985-1998)

9.2 Data and biological inputs

Length compositions of the Venezuelan production of red snapper from French Guiana have been sampled since 1985 (Table 9.2).

Discard data are not available and, in fact, the very small fishes, probably unmarketable, are used as bait for the hooks. The amount of bait (the sardine caught in the Gulf of Paria) is often insufficient for covering their needs during all the voyage on the Guiano-Brazilian shelf.

The biological parameters are given in Table 9.7. The growth parameters and the value for natural mortality are from Perodou (unpublished thesis, 1994). Preliminary works using the programme ELEFAN has been done in 1998. They give information consistent with the values calculated by Perodou. In the paper, the lengths of fishes are given exclusively as fork-length.

Table 9.2 Data and input parameters for *L. purpureus* caught by Venezuelan - Hand-lines - # 5/0 and # 6/0, in French Guiana

Sampling year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Numbers of samples	48	48	48	48	48	48	48	48	48	48	48
Mean number of snappers by sample	324	602	288	282	575	426	374	291	270	175	388

Biometry		
Input Parameters	**Values**	**Sources**
von Bertalanffy Growth: K year^{-1}	0.12	Pérodou 1994
L_∞ (fork length in cm)	95.0	
Natural Mortality year^{-1}	0.20	
Age at 100% maturity (years)	4	
Length/weight relationship: a	0.01489	
Length/weight relationship: b	3.01767	
Conversion factors:		Prevost 1989
Nominal weight from gutted weight	1.105	
Total length from fork length	1.087	

9.2.1 Comments on the general quality of the inputs

Length frequency data, from 1986 onwards, are available on a monthly basis from samples of the landings only in Cayenne. The fish landed in Venezuela are not sampled.

Information on the landings composition and the numbers of hours fished per voyage are obtained from logbooks. The exact situation of the daily fishing is given by the skipper for a zone and a depth (see map). No discard sampling programmes have been undertaken.

For the present assessment, the series 1988 to 1998 was retained for running length cohort analysis (LCA) and the complete series (1986-1998) for the VPA.

9.2.2 Landings and effort

As for penaeid shrimps, the capture of the snappers is not sorted on board and the production of the three species, *Lutjanus purpureus, Lutjanus synagris* and *Rhomboplites aurorubens* are estimated through the scientific sampling (Table 9.3).

Table 9.3 Estimated catches in tonnes of snappers by the Venezuelan fleet in the French Guiana EEZ

	Lutjanus purpureus	***Rhomboplites aurorubens***	***Lutjanus synagris***
1986	677	17	1
1987	716	18	1
1988	1116	32	4
1989	1366	35	3
1990	1278	51	3
1991	1115	19	1
1992	1197	94	3
1993	1383	135	1
1994	1468	60	4
1995	1462	119	4
1996	2110	137	10
1997	1578	117	10
1998	1840	179	2

The landings are strongly correlated with fishing effort (R^2=0.82, df=11). A correlation between landings per unit effort and effort can be detected (R^2=0.40, df=11), but is heavily dependent on the 1986 data point. The relationship essentially disappears with the removal of that point (R^2=0.08, df=12), suggesting it is unreliable.

In spite of a control of the use of licences in Cayenne, it is likely that a part of the catches can be sold in Paramaribo, Suriname and that the share of the catch that returns to Venezuela is therefore not known. When a boat sells its catch in Paramaribo, there are no data (effort and landing) on the corresponding trip. Illegal landings should be included, but data are not available. Snapper landings in Cayenne are probably under estimated.

The main bycatch of the hook and line fishery comprises ten species of groupers, which are not landed in Cayenne, various Carangidae, pelagic sharks, which are processed on board (salted and dried) and, seasonally, *Scomberomorus* spp. (king mackerels).

The estimated total directed effort follows exactly the number of boats in the time series. Two years' effort data may be inaccurate. In 1986 and 1987, the regulation had just started and the licence system did not work correctly.

In 1996, there was an observed increase in effort. The list of licensed boats was revised, day after day, which permitted the replacement of boats leaving periodically the fishery, so this increase could be an artefact of the licensing process rather than any real increase in effort.

The average CPUE of the red snapper fleet has remained around 28 kg hour^{-1} fishing for the last 10 years (Fig. 9.2). CPUE is usually highest from June to November (Fig. 9.3*).*

9.2.3 Mean size

Mean sizes (fork-length) in the landings (Fig. 9.4) are available since 1986. There has been a marked decrease in mean size of red snapper in the landings since 1991. That decrease corresponds to an important increase in the number of small specimens in the landings. There has been a trend of increasing numbers of fish landed as the mean fish size has decreased (Fig. 9.4). The size of the traditional hooks (# 5/**0** and #6/**0**) has remained unchanged, suggesting selectivity has not changed through changes in gear used.

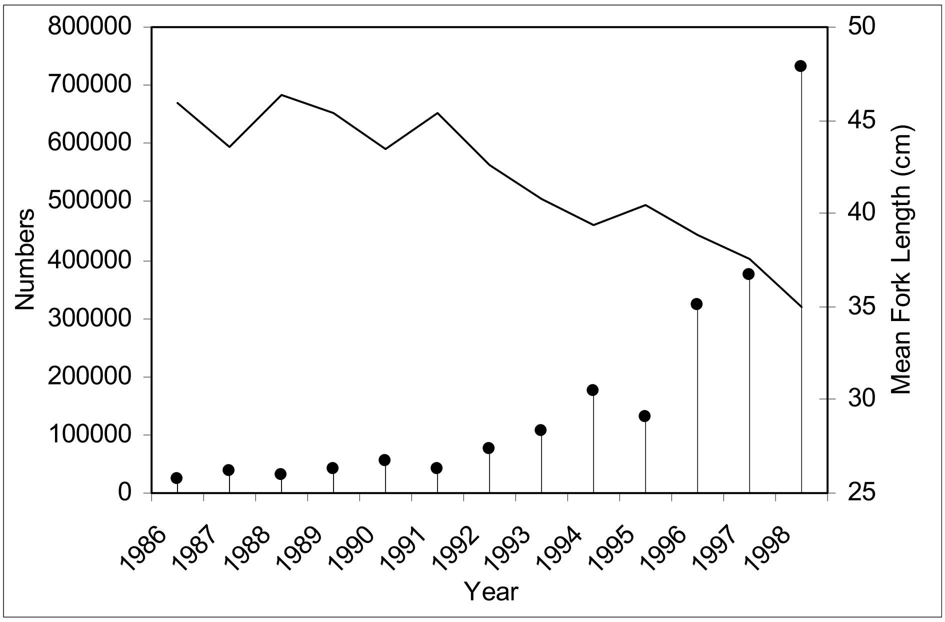

Figure 9.4 Total number of *L. purpureus* (•) and mean fork-length in the range 20-32cm (—) in landings of the Venezuelan fleet in French Guiana from 1986 to 1998. The the average size declines as the estimated numbers of fish in the landings is rapidly increasing

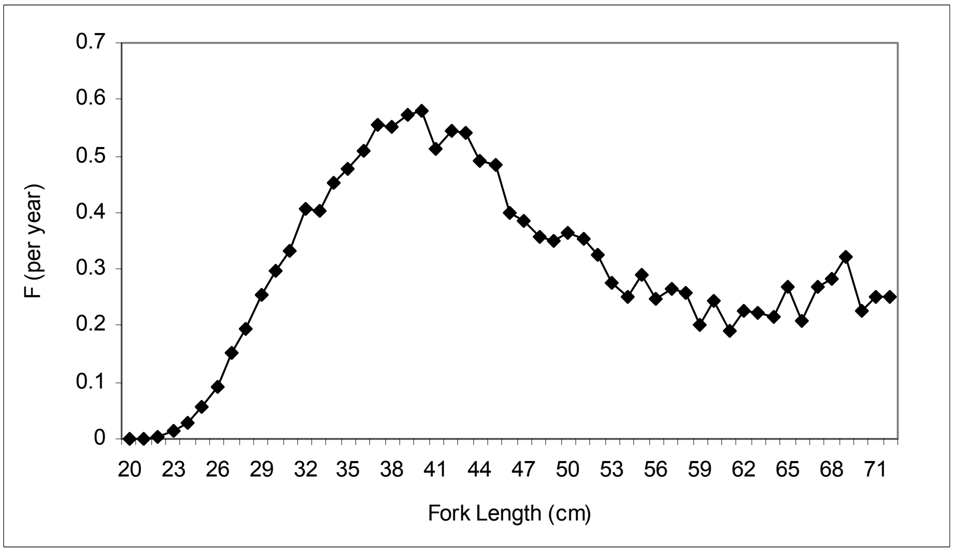

Figure 9.5 Fishing mortality by fork length from LCA for *L. purpureus*

9.3 Assessments

9.3.1 Length cohort analysis

The Length Cohort Analysis used the average annual length compositions, from 1988 to 1998. LCA assumes the fishery was at equilibrium during this period. The terminal F chosen is F = 0.25, which gave for the lengths 55 to 67cm better smoothed values of F.

Input data and results are given on Table 9.4. The results suggest a peak selectivity around 38cm FL (Fig. 9.5). The yield-per-recruit curve suggests that the F_{MSY} is exceeded by at least 25% (Fig. 9.6), while the spawning stock biomass per recruit (SSB/R) has reached very low levels.

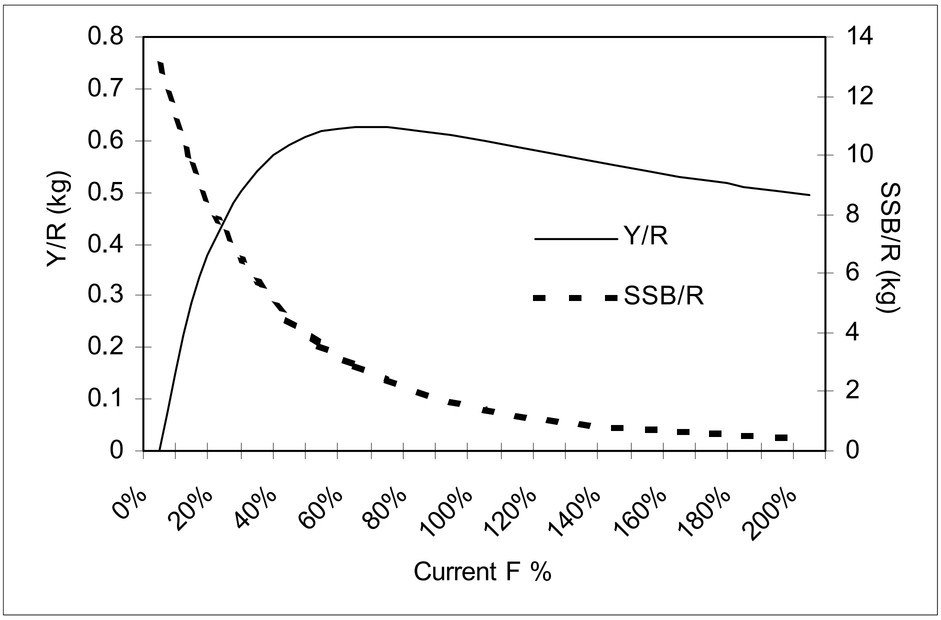

Figure 9.6 Y/R and SSB/R (in kg) from LCA for *L. purpureus* in French Guiana

Table 9.4 Input values and results of Length Cohort Analysis (LCA) *L. purpureus* in French Guiana. The von Bertalanffy growth model used parameters: L_∞ = 95cm. K = 0.12 year^{-1}

Length (cm)	Catches	M (year^{-1})	dt	Fdt	F (year^{-1})	Z (year^{-1})	Zdt	Average number attaining size
20	182	0.2	0.1119	0.0001	0.0008	0.2008	0.0225	2090638
21	308	0.2	0.1134	0.0002	0.0013	0.2013	0.0228	2044206
22	1191	0.2	0.1149	0.0006	0.0052	0.2052	0.0236	1998069
23	2873	0.2	0.1166	0.0015	0.0128	0.2128	0.0248	1951482
24	6506	0.2	0.1182	0.0035	0.0293	0.2293	0.0271	1903679
25	12356	0.2	0.1199	0.0068	0.0565	0.2565	0.0308	1852772
26	19988	0.2	0.1217	0.0113	0.0931	0.2931	0.0357	1796661
27	31650	0.2	0.1235	0.0187	0.1511	0.3511	0.0433	1733728
28	39684	0.2	0.1253	0.0245	0.1955	0.3955	0.0496	1660183
29	49577	0.2	0.1272	0.0323	0.2538	0.4538	0.0577	1579904
30	55492	0.2	0.1292	0.0384	0.2974	0.4974	0.0643	1491263
31	59018	0.2	0.1312	0.0437	0.333	0.5330	0.0699	1398447
32	67795	0.2	0.1333	0.0541	0.4059	0.6059	0.0808	1303976
33	63030	0.2	0.1355	0.0546	0.4028	0.6028	0.0817	1202772
34	65930	0.2	0.1377	0.0622	0.4515	0.6515	0.0897	1108438
35	64699	0.2	0.1401	0.0669	0.4779	0.6779	0.0949	1013298
36	63602	0.2	0.1425	0.0726	0.5094	0.7094	0.1011	921515
37	63415	0.2	0.1449	0.0804	0.5546	0.7546	0.1094	832935
38	57540	0.2	0.1475	0.0814	0.5521	0.7521	0.1109	746641
39	54116	0.2	0.1502	0.0858	0.5713	0.7713	0.1158	668245

Length (cm)	Catches	M (year^{-1})	dt	Fdt	F (year^{-1})	Z (year^{-1})	Zdt	Average number attaining size
40	49677	0.2	0.1529	0.0886	0.5791	0.7791	0.1191	595171
41	39931	0.2	0.1558	0.0799	0.5127	0.7127	0.1110	528326
42	38431	0.2	0.1587	0.0862	0.5429	0.7429	0.1179	472811
43	34603	0.2	0.1618	0.0874	0.5401	0.7401	0.1198	420214
44	28469	0.2	0.1650	0.0808	0.4897	0.6897	0.1138	372788
45	25575	0.2	0.1684	0.0814	0.4835	0.6835	0.1151	332686
46	19264	0.2	0.1718	0.0684	0.3979	0.5979	0.1027	296525
47	17260	0.2	0.1754	0.0679	0.387	0.5870	0.1030	267575
48	14671	0.2	0.1792	0.0639	0.3563	0.5563	0.0997	241392
49	13322	0.2	0.1832	0.0641	0.35	0.5500	0.1007	218485
50	12726	0.2	0.1873	0.0679	0.3625	0.5625	0.1053	197548
51	11389	0.2	0.1916	0.0675	0.3524	0.5524	0.1058	177798
52	9670	0.2	0.1961	0.0636	0.3245	0.5245	0.1028	159943
53	7631	0.2	0.2008	0.0555	0.2761	0.4761	0.0956	144311
54	6497	0.2	0.2058	0.0519	0.2521	0.4521	0.0930	131152
55	6944	0.2	0.2110	0.0612	0.2899	0.4899	0.1034	119501
56	5471	0.2	0.2165	0.0533	0.2461	0.4461	0.0966	107766
57	5475	0.2	0.2222	0.0589	0.265	0.4650	0.1033	97847
58	4957	0.2	0.2283	0.0592	0.2592	0.4592	0.1048	88240
59	3584	0.2	0.2348	0.0473	0.2013	0.4013	0.0942	79457
60	4041	0.2	0.2416	0.0589	0.244	0.4440	0.1073	72312
61	2958	0.2	0.2488	0.0478	0.1921	0.3921	0.0976	64958
62	3254	0.2	0.2564	0.0583	0.2274	0.4274	0.1096	58921
63	2940	0.2	0.2646	0.0589	0.2224	0.4224	0.1118	52804
64	2645	0.2	0.2732	0.0593	0.2169	0.4169	0.1139	47220
65	3003	0.2	0.2825	0.0761	0.2694	0.4694	0.1326	42136
66	2136	0.2	0.2924	0.0614	0.2101	0.4101	0.1199	36903
67	2487	0.2	0.3031	0.0815	0.269	0.4690	0.1421	32733
68	2337	0.2	0.3145	0.0887	0.2821	0.4821	0.1516	28396
69	2367	0.2	0.3268	0.1056	0.323	0.5230	0.1709	24401
70	1470	0.2	0.3402	0.0768	0.2257	0.4257	0.1448	20566
71	1454	0.2	0.3547	0.0884	0.2493	0.4493	0.1594	17793
plus group	8429	0.2			0.25	0.4500		15172

9.3.2 Age-based assessment

A trial analysis was carried out converting length to age based on a growth model. Length compositions were divided into age compositions according to the growth parameters of the species. This species is thought to spawn during the whole dry season offshore and during the wet season, the larvae and juveniles are progressively recruited to the fishery on muddy grounds in coastal waters.

The length distributions for years 1986 to 1998 were split into 9 nominal age groups (plus-group at 10), using a size distribution slicing method. The age compositions were analysed using a tuned VPA (extended survivors analysis; CEFAS, Lowestoft, UK package containing slicing, tuning and VPA software). As it is a new assessment method for this stock, the tuning was performed with the default options: catchability for all ages was assumed to be independent of stock size, on the reduced CPUE series for years 1993-1998.

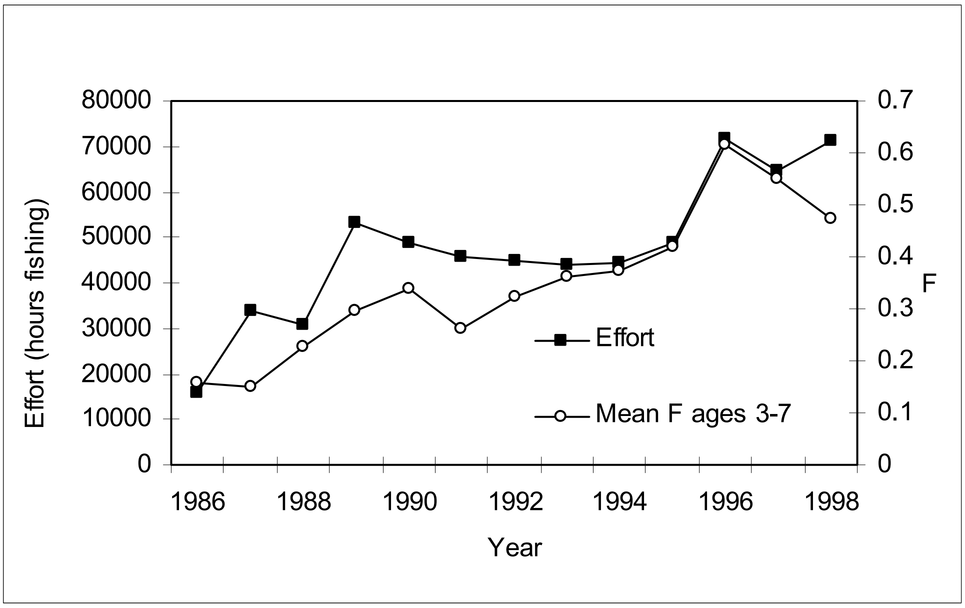

Figure 9.7 Effort and F for *L. purpureus.* There has been a large increase in F in recent years

The results indicated large increase in effort and F (Fig. 9.7). There was a strong log-linear relationship between fishing mortality and fishing effort (R^2=0.90, 11df).

VPAs can provide biased estimates of population parameters for the most recent years in the series, especially when there is a recent trend in fishing mortality. This is the case for these data where fishing mortality and fishing effort have increased over the last 4 years (Fig. 9.7). Retrospective analysis was used to explore the impacts of such trends and estimate a correction factor on recruitment. Retrospective analysis consists of running multiple VPAs, with a minimum number of years for the first series and increasing the length of the series by adding an additional year on each subsequent run. Hence, the first series was 1986-1991, the second 1986-1992 and so on, creating 8 separate VPAs. These analyses provide an indication of how recent estimates of population parameters change as new data are added.

We conducted retrospective analysis of the data for *L. purpureus* and analysed the trends in recent estimates of recruitment and fishing mortality of the age 3 group (Fig. 9.8 and 9.9). In all cases recruitment estimates are overestimated for recent years, but this overestimation decreases as the number of years of data used for such estimation of recruitment increases. Overestimation is large for estimates made with only one year of data (70%) but decreases quickly and is only 10% after 5 years. We fitted an exponential function to such overestimation and used it to correct the estimates of recent recruitment made with the most recent data (Fig. 9.10).

The resulting recruitment trend (dotted line) is considerably different from the one shown by the uncorrected recruitment estimates provided by the VPA (drawn line). The corrected estimates suggest that there may not have been any increases in recruitment since 1991, quite unlike the suggestion from the VPA that recruitment had continued to increase since 1991 (Fig. 9.11).

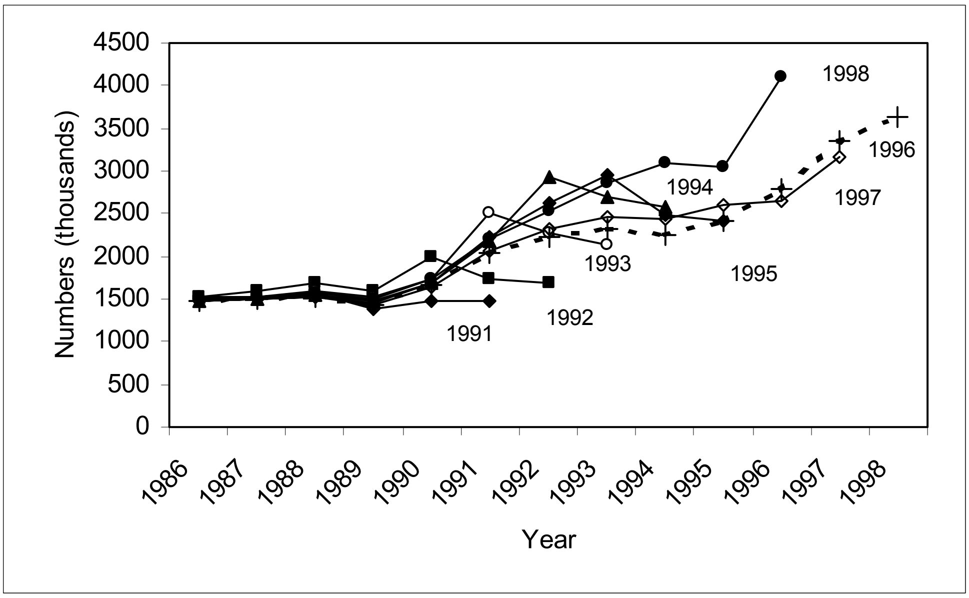

Figure 9.8 Retrospective VPA results of recruit numbers by year for *Lutjanus purpureus* in French Guiana, from 1986 to 1998

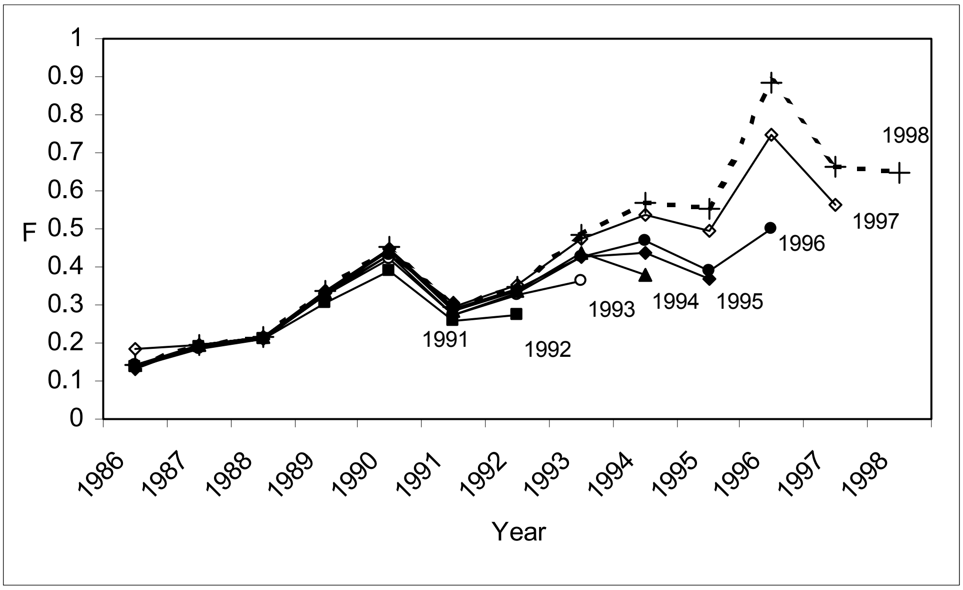

Figure 9.9 Retrospective VPA results of F for age 3 for *Lutjanus purpureus* from 1986 to 1998

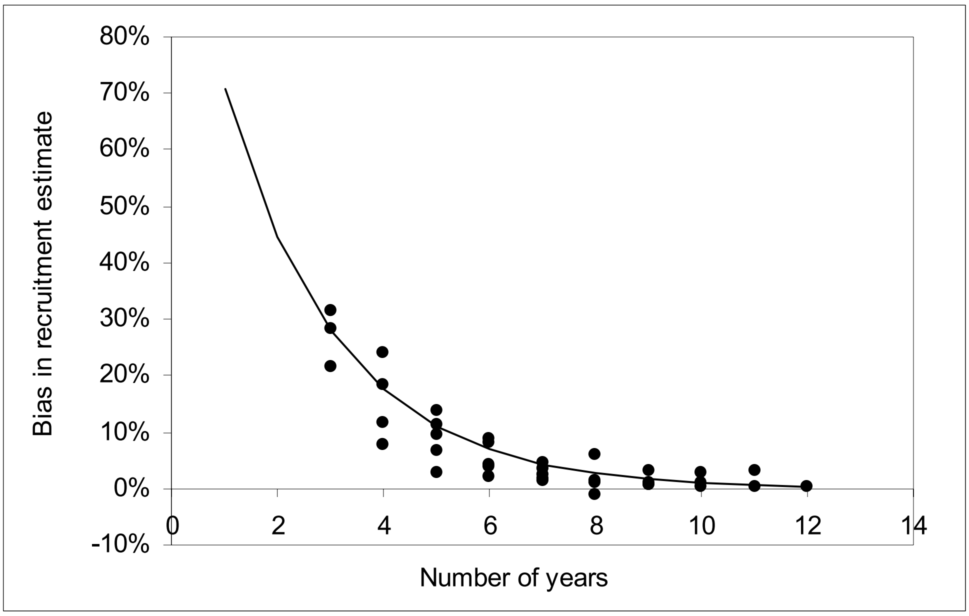

Figure 9.10 Overestimation of recruitment from retrospective VPA in *L. purpureus* in French Guiana, from 1986 to 1998

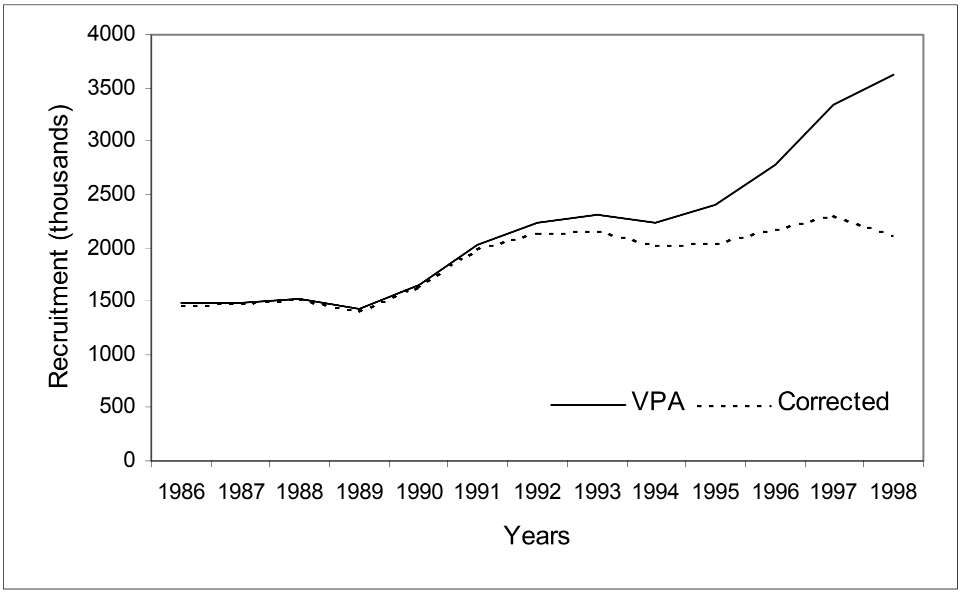

Figure 9.11 Overestimation of recruitment from retrospective VPA and corrected values for *L. purpureus*, from 1986 to 1998

The retrospective VPA also suggested that fishing mortality estimates were underestimated by the VPA. We looked at biases for age group 3, the main target of the present fishery. Biases were not as large as those observed for recruitment. The estimate of F for age 3 and for the most recent year is underestimated by 20%, but by year 5 this has fallen to 5%. The trend of F does not change substantially and continues to suggest that there have been very large increases in F over the last 10 years (Fig. 9.12).

To moderate that trend in biomass, a recalculation of stock numbers at age was carried out according to the following method. The numbers at age 1 in 1996, 1997 and 1998 were corrected by replacing the numbers at age 1 to 4 of the 1999 age compositions (at 1st January) with the numbers of the same ages from the arithmetic mean on the series 1990-1995, using the formula: $N_t = N_o\, e^{-zt}$. That range of years was chosen outside the present trend.

The corrected data produces similar patterns to the uncorrected VPA, but the trends have been reduced. Mean Fs on ages 3 to 7 have increased from 1986 to 1997 with the increasing effort and there has still been an increase in recruitment between 1988 and 1990 (Fig. 9.11).

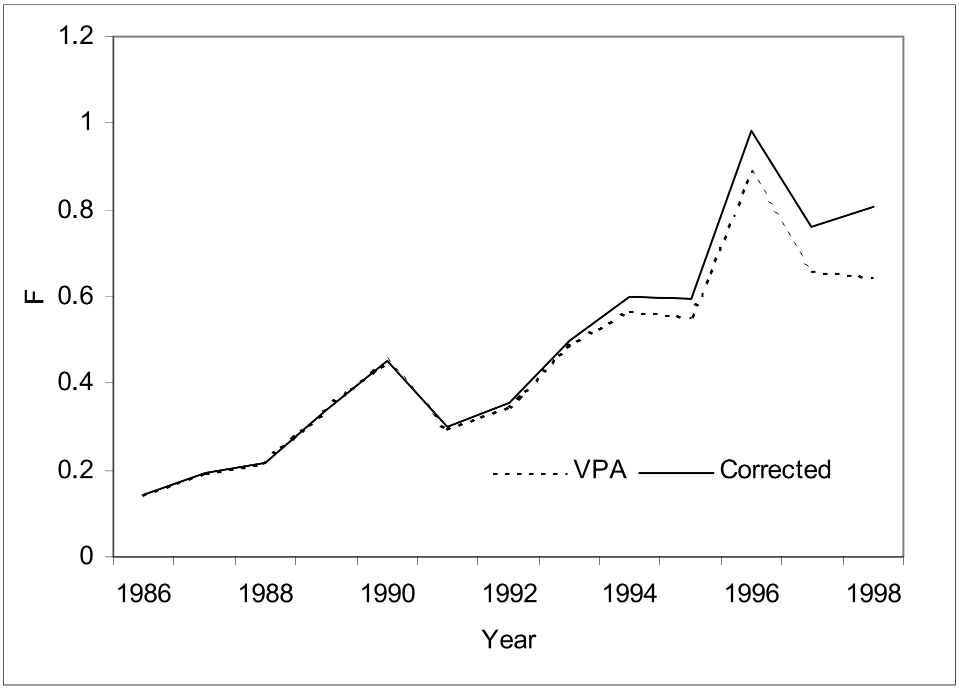

Figure 9.12 Overestimation of F by VPA and corrected values from restropective VPA for *Lutjanus purpureus* in French Guiana, from 1986 to 1998

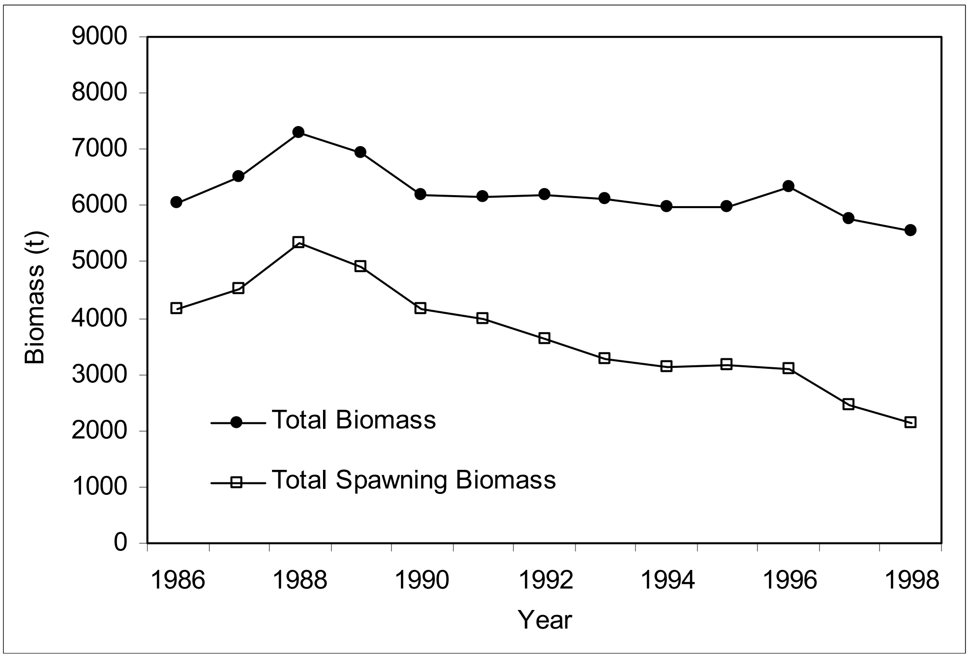

Figure 9.13 Biomass and SSB based on the corrected VPA. There has been a decline in biomass in recent years

One of the main requirements for a VPA is that the catch at age data represent all the catches from the stock. This is not strictly the case for the data from French Guiana. We do not know the real limits of the stock and whether it is shared with those of neighbouring countries. In addition, we know that part of the catch of red snappers caught in French Guyana is landed elsewhere by Venezuelan vessels. It seems that this catch landed outside

French Guyana may be mainly composed of large fish. Recently, there is also a new group of vessels from the French Antilles that harvest *Lutjanus* within French Guyana and those do not land their catch in Cayenne. Finally, it is also known that discards of juvenile red snappers occur in the shrimp fishery.

To get an idea of the possible effects of having incomplete catch data we conducted an analysis that tested the effects of underestimation of the number of large fish caught. We assumed that there was no bias at the beginning of the time series, but that the under-reporting of large fish increased linearly with size and time and that 30% of large fish went unreported.

The impact of such level of under-reporting can be seen in the estimates of recruitment, fishing mortality and spawning stock biomass (Fig. 9.14). The effect is relatively constant with time for recruitment and for the average fishing mortality. It therefore would not change stock trends, but rather the absolute estimates of those two parameters. Recruitment would be underestimated by10% and fishing mortality would be overestimated by 10% (Fig. 9.14).

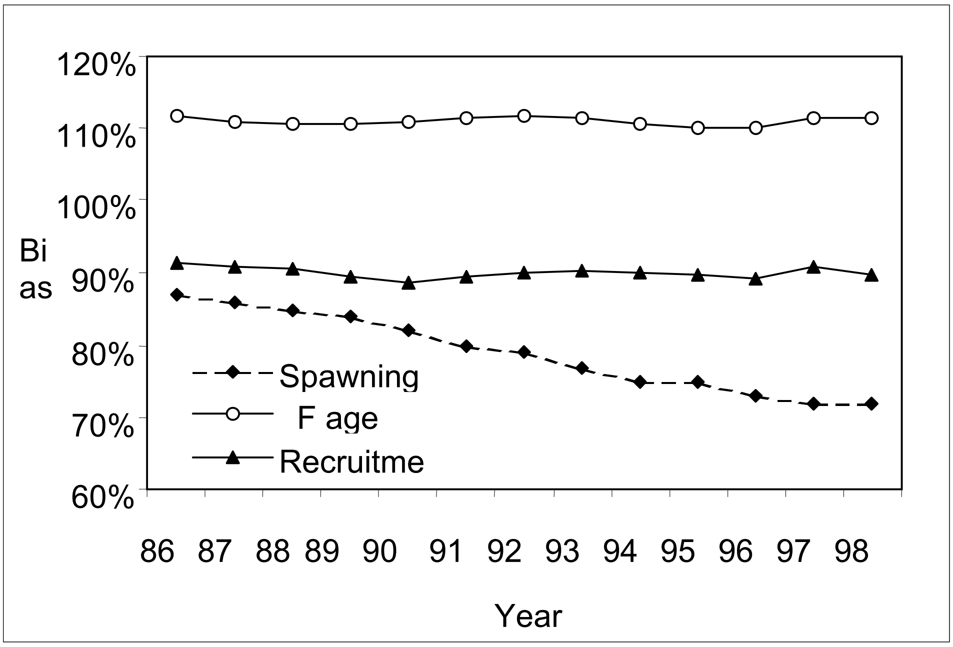

Figure 9.14 Potential bias in spawning biomass, F and recruitment for from unreported catches of *Lutjanus purpureus*

For the spawning stock biomass there is a trend in the bias with time. This is a direct result of the fact that we assumed that the rate of under-reporting has increased with time and specially for large fish (that make up the bulk of the spawning stock). The bias is large for recent years reaching 30%.

9.4 Stock - recruitment and yield per recruit

Yearly recruitments were plotted against SSB of the preceding year (Figure 9.15). The fitted model suggests a strong inverse correlation between SSB and recruitment, reflecting the opposite trends between F and recruitment in the analysis. It is difficult to say whether the estimated recruitment is a true recruitment or a mixed recruitment comprising juveniles and young individuals migrating from the muddy grounds.

A yield per recruit and a spawning stock biomass per recruit (SSB/R) analyses were carried out using the Thompson and Bell method, available in the Lowestoft Virtual Population Analysis Package. The yield per recruit analysis (Fig. 9.16) suggests that F_{MSY} is 50% of the current mean F (ages 3-9). These results are more pessimistic than those obtained with the yield per recruit analysis calculated with LCA. The SSB/R results show the usual sharp decrease in SSB/R at higher fishing mortality levels. This contrasts with the abnormal stock recruitment relationship in Fig. 9.15.

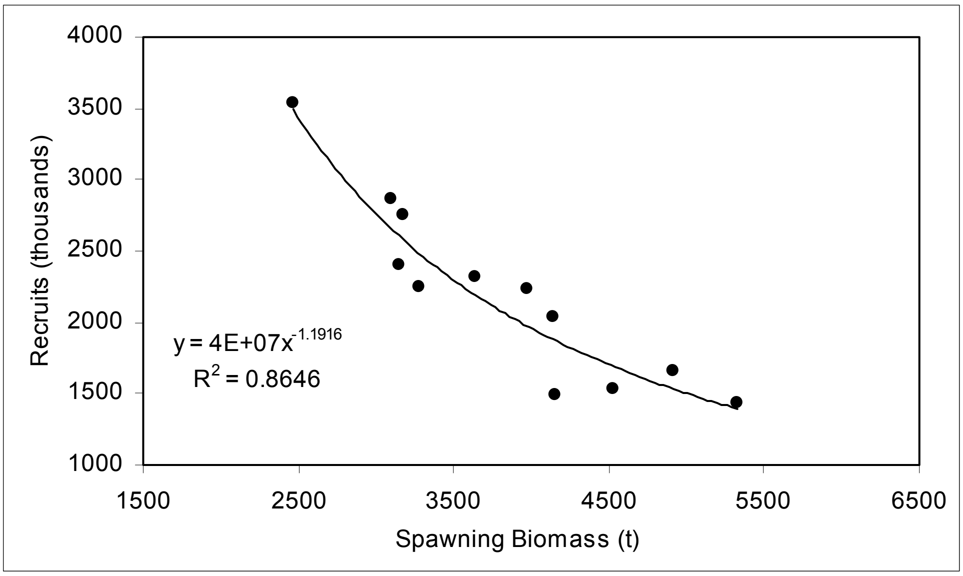

Figure 9.15 Relationship between SSB and level of recruits in the following year of *Lutjanus purpureus,* based on the corrected VPA. The results suggest a strong density dependence between spawning stock and recruitment

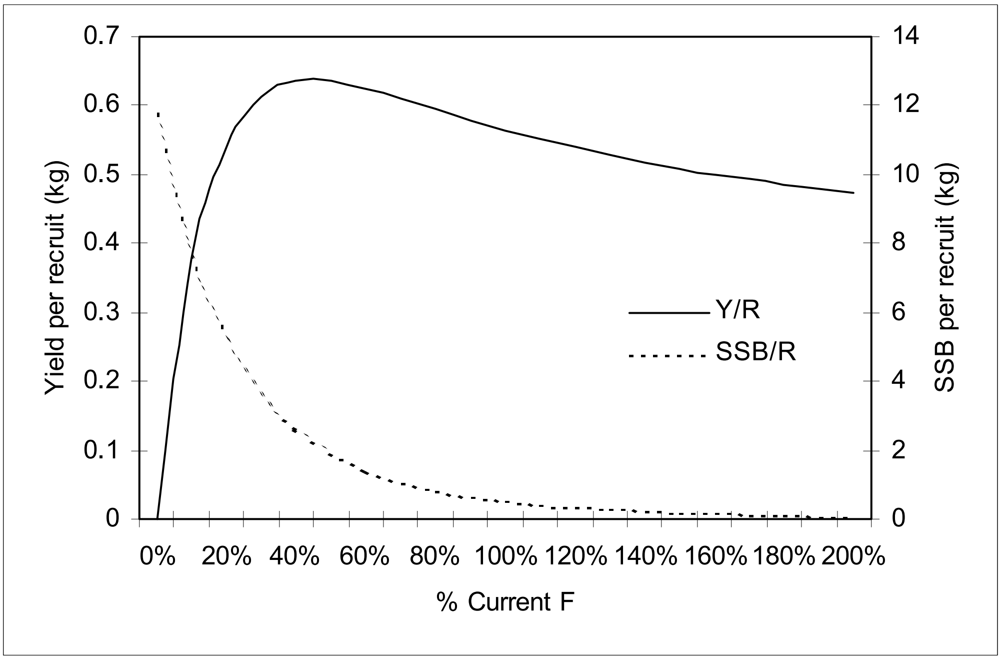

Figure 9.16 Yield per recruit and spawning stock biomass per recruit for different fishing mortalities, as a proportion of current mean F for ages 3-9. Results are taken from the corrected VPA

9.5 Discussion and management considerations

The growth parameters remain one of the main sources of uncertainty in these assessments. Other sources of uncertainty are related to the estimation of fishing effort and the annual length compositions of the catches by shrimp trawlers. Fishing effort should also be investigated, mainly for 1987 and 1988. Finally, the analysis would be enhanced with information of all catches (including discards), which are most likely taken from this stock

The main problem with the assessment, is the interpretation of the positive relationship between F and recruitment (Fig. 9.17) estimated from the VPA. The retrospective VPA suggests that this relationship could be the result of bias and correlated estimates of F and recruitment. However, the red snapper does cannibalise its young and is territorial, which means that when a large red snapper is caught, a source of natural mortality for juveniles is directly eliminated and the reef where the population lives can shelter more young fishes migrating from the muddy grounds. It is therefore possible there is a density-dependent feedback, but the VPA may tend to grossly overestimate that effect.

In general, the numbers of young fish has been increasing in the landings. The VPA has interpreted this as increased recruitment, but may also be due to increased availability of young fish in the fishing grounds. If this is the case, then F is increasing for juveniles, which is offset by a possible lower natural mortality by predation.

Given the uncertainty of the results, it is important to avoid any further increases in effort without improvements in the assessment.

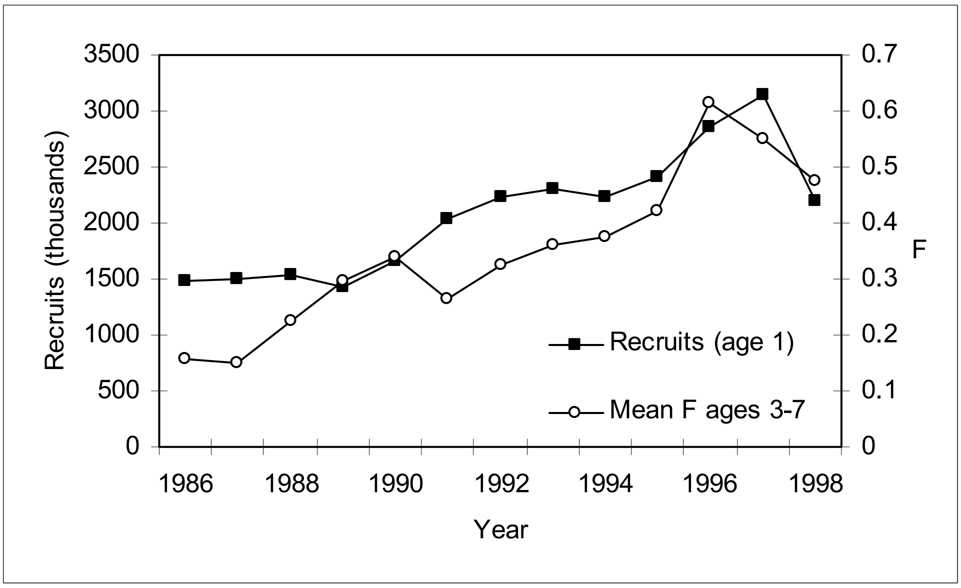

Figure 9.17 Fishing mortality and recruitment estimates for *Lutjanus purpureus*, from the uncorrected VPA. There was a strong log-linear relationship between recruitment and F estimates (R^2=0.71, df=11)